MASTER OF SCIENCE
IN
MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION

EFFECTS OF NAVIGATION AIDS ON HUMAN ERROR IN A COMPLEX NAVIGATION TASK

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This thesis investigates land navigators' performance differences in land navigation when different navigation aids are used. The question that this thesis attempts to answer is whether the use of Global Positioning System (GPS) in land navigation results in a performance dependency, and, if so, whether dependency adversely affect performance? To address these questions an experiment was conducted to see if the use of GPS makes map and compass training obsolete.

The participants were divided into two training groups, such as map and compass navigation and GPS navigation. The experiment studied human performance differences, human error, and transfer of training while participants navigated using only GPS in the first part, and map and compass in the second part of the experiment.

The results suggested that map and compass training is always strongly required. A map and compass native land navigator outperforms the GPS native land navigator when GPS is not accessible. This evidence suggests that a military land navigator, in particular, should know both navigation techniques and should be able to switch from one to the other without any hesitation.

KEYWORDS: Land Navigation, GPS, Map, Compass, Distance-Azimuth Chart, Distance Error, Off-Route Error, Human Error, Checkpoint

AGENT-BASED SOLDIER BEHAVIORS IN DYNAMIC 3D VIRTUAL ENVIRONMENTS

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Human behavior in virtual environments is commonly implemented as a finite state machine. This programming approach can be effective and challenging against human players, but its ability to realistically simulate the behavior of cooperative groups of soldiers is limited. This thesis covers the development of an agent-based system to control the behavior of infantry in 3D virtual environments. The system design divides the cognitive process into four modules: perception, mental model, goal decision, and action resolution. Each module attempts to simulate both strengths and weaknesses of human perception and cognition, including instinctive reactions, perceptual error, memory degradation, context-dependent decision-making, and inference. Additionally, the soldiers are influenced by the actions and decisions of the agents around them, enabling cooperation. The resultant agent system was incorporated into a game-like interface and compared to a similar commercial game with standard AI. Overall, 72% of

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the test subjects thought that the agent behaviors were *Mostly Realistic* or *Totally Realistic*, and 81% found them to be equal to or better than those in the commercial game.

KEYWORDS: Human Behavior Modeling, Agent Systems, Infantry Combat Modeling, Cognitive Modeling, Game Artificial Intelligence

THE EFFECT OF SOUND DELIVERY METHODS ON THE USER'S SENSE OF PRESENCE IN A VIRTUAL ENVIRONMENT

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The purpose behind this thesis was two-fold. First, the effect of sound delivery on a user's sense of presence in a virtual environment was investigated. Second, the physiological responses of electrodermal activity, heart rate, and temperature were measured and correlated to the user's subjective sense of presence in an attempt to investigate an objective measure of presence.

A computer based first-person shooter game (Medal of Honor: Allied Assault™) was utilized as the virtual environment. The independent variable was the sound delivery method (no sound, 5.1 surround sound, headphones, and headphones with subwoofer). The dependent variables were physiological responses and subjective questionnaire responses.

The addition of sound to the virtual environment contributed to the user's sense of presence significantly. This was evident in the physiological responses of electrodermal activity and temperature and questionnaire scores. Temperature was not only affected by the addition of sound, significant changes even occurred between the speaker and headphone sound delivery methods. This is a natural bodily reaction when exposed to fear, which suggests speakers created a higher sense of fear and possibly induced a higher level of presence in participants.

KEYWORDS: Presence, Virtual Environments, Physiological Responses, Subjective Presence Measurement, Objective Presence Measurement

TERRAIN LEVEL OF DETAIL IN FIRST PERSON-GROUND PERSPECTIVE SIMULATIONS

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The Army Game Project at the Naval Postgraduate School is utilizing Epic's Unreal game engine to create a realistic first person infantry simulation. The project involves both indoor and outdoor spaces, including terrain datasets larger than normally supported by the Epic engine. While there has been extensive research relating to terrain rendering algorithms, they are unsuitable for this system due to hardware requirements, task limitation, or inefficient memory management. These limitations can be addressed by modifying the original terrain algorithm to include multiple levels of detail for complex terrain. This method raises new issues with projected textures, transparent textures, and multi-resolution rendering; therefore the implementation technique includes resolution for these concerns as well. The Epic world editor was also modified to enable world designers control of these levels of detail. Performance tests have

shown that this terrain level of detail system significantly improves display times, thereby allowing greater terrain complexity while maintaining interactive frame rates. Rendering times in environments with small terrains improved almost 40%, while large complex terrain environments (km^2 at 1m resolution) fared even better.

KEYWORDS: Level of Detail, Terrain, Quad Tree, Alpha, Hysteresis, Mesh